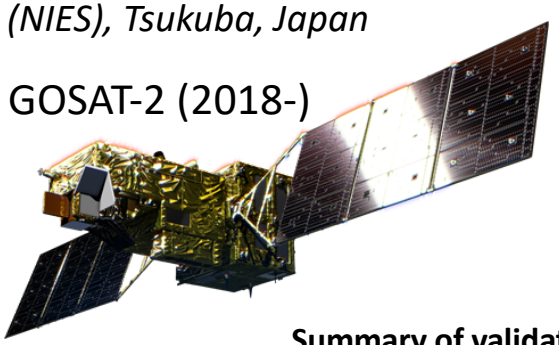
Validation of recent versions for the GOSAT and GOSAT-2 FTS SWIR L2 products

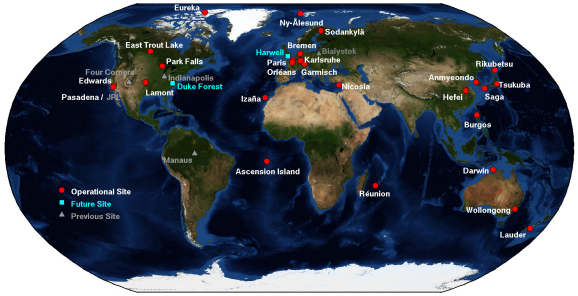
Isamu Morino [1], Yukitomo Tsutsumi [1], Osamu Uchino [1], Tran Thi Ngoc Trieu [1], Matthias M. Frey [1], Yukio Yoshida [1], Tsuneo Matsunaga [1], Akihide Kamei [1], Makoto Saito [1], Hibiki M. Noda [1], and TCCON partners

[1] National Institute for Environmental Studies (NIES), Tsukuba, Japan

GOSAT (2009-)



GOSAT-2 (2018-)



The TCCON Data Archive https://tccondata.org/

Used data

1. **GOSAT SWIR L2 data: V02.90/02.91**
   - The validation was made using the data V02.90 during April 2009～May 2020 and the data V02.91 during June 2020~March 2021.
2. **GOSAT-2 SWIR L2 Full Physics data:**
   - The validation was made using the V01.04 data during March 1, 2019～May 18, 2020
   - Area type: Land and Ocean (Land: >= Land Fraction 10%, Ocean: < Land Fraction 10%)
3. **GOSAT-2 SWIR L2 PROXY data:**
   - The validation was made using the V.01.03 data during March 1, 2019～February 29, 2020.
   - Area type: Land and Ocean (Land: >= Land Fraction 10%, Ocean: < Land Fraction 10%)
4. **TCCON data: GGG2014**
   - obtained from the TCCON data archive (https://tccondata.org)
   - GOSAT and GOSAT FP: without consideration of column averaging kernels and a priori profiles for the quick validation analysis
   - data whose measurement altitude difference between GOSAT and TCCON are larger than 500 m are not used.

Coincidence criteria for comparisons

1. **GOSAT SWIR L2 data:**
   - obtained by ±2º coincidence criteria (±2º box area centered at the TCCON site)
2. **TCCON data :**
   - averaged over within ±30 min of GOSAT overpass time

Summary of validation

GOSAT (V02.90/20.91)

Area	Gain	XCO_2			XCH_4			XH_2O		
		N	Bias	S.D.	N	Bias	S.D.	N	Bias	S.D.
Land	H	8727	-0.41 ppm (-0.10%)	2.12 ppm (0.53%)	8746	-2.22 ppb (-0.12%)	12.20 ppb (0.67%)	8746	-59.75 ppm (-1.13%)	376.28 ppm (18.98%)
Land	M	1591	0.65 ppm (0.16%)	2.03 ppm (0.50%)	1591	10.71 ppb (0.58%)	19.77 ppb (1.07%)	1591	161.57 ppm (14.24%)	580.51 ppm (35.48%)
Ocean	H	139	-1.34 ppm (-0.33%)	2.18 ppm (0.54%)	139	0.24 ppb (0.01%)	13.50 ppb (0.74%)	139	-110.58 ppm (-2.12%)	622.99 ppm (12.18%)

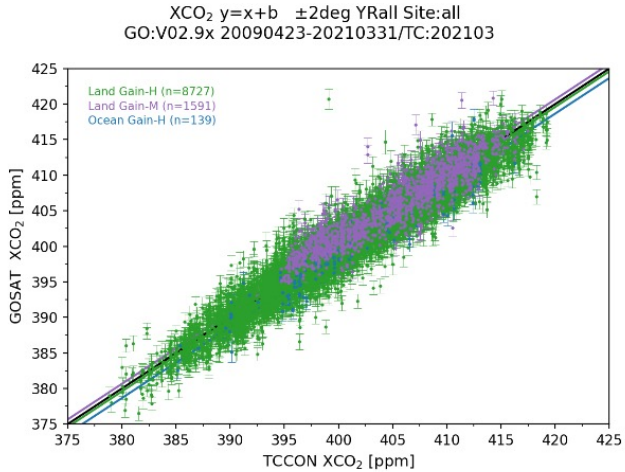
GOSAT-2

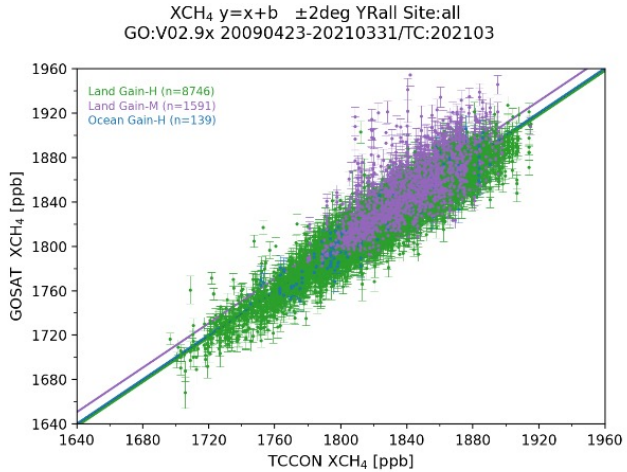
	Area	XCO_2			XCH_4		
		N	Bias	S.D.	N	Bias	S.D.
Full Physics (V01.04)	Land	2640	2.34 ppm (0.57%)	4.04 ppm (0.98%)	2654	-0.03 ppb (-0.00%)	19.33 ppb (1.04%)
	Ocean	92	-0.14 ppm (-0.03%)	5.79 ppm (1.41%)	102	-11.7 ppb (-0.63%)	22.97 ppb (1.25%)
		XH_2O			XCO		
		N	Bias	S.D.	N	Bias	S.D.
	Land	2654	51.84 ppm (3.86%)	413.86 ppm (21.28%)	2650	21.16 ppb (25.05%)	8.45 ppb (10.27%)
	Ocean	104	-43.76 ppm (1.4%)	567.88 ppm (16.25%)	101	18.66 ppb (22.92%)	7.64 ppb (8.91%)

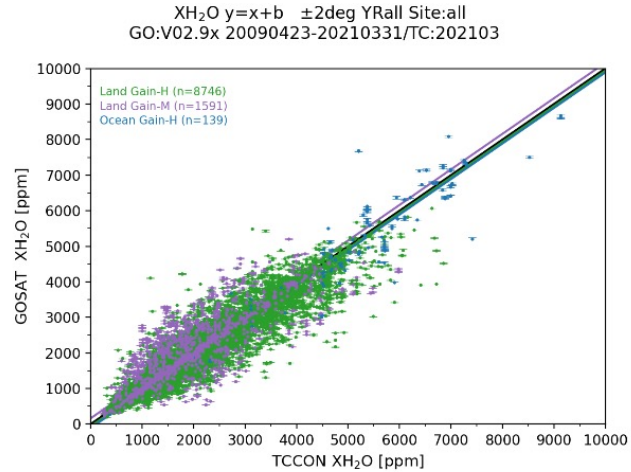
	Area	XCH_4			XCO		
		N	Bias	S.D.	N	Bias	S.D.
PROXY (V01.03)	Land	4340	-5.93 ppb (-0.32%)	13.57 ppb (0.73%)	2474	10.63 ppb (12.55%)	8.28 ppb (9.50%)
	Ocean	226	-13.00 ppb (-0.71%)	15.94 ppb (0.86%)	96	7.79 ppb (9.55%)	11.37 ppb (13.50%)

Scatter diagrams of GOSAT FTS SWIR L2 (V02.90/02.91) and TCCON at all TCCON sites and differences between them with 1 standard deviation (±2 degree)

N: total number of matched data





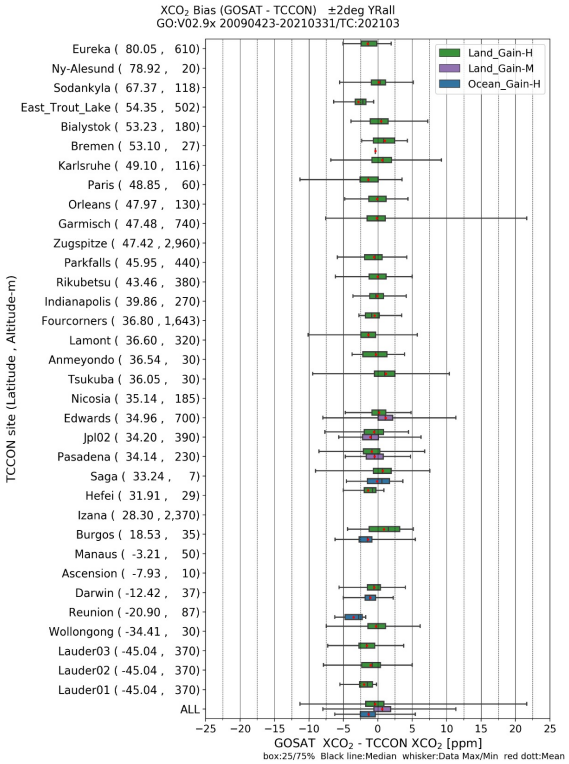


Land Gain H N= 8727	-0.41 ± 2.12 ppm (-0.10 ± 0.53%)	
Land Gain M N= 1591	0.65 ± 2.03 ppm (0.16 ± 0.50%)	
Ocean Gain H N= 139	-1.34 ± 2.18 ppm (-0.33 ± 0.54%)	

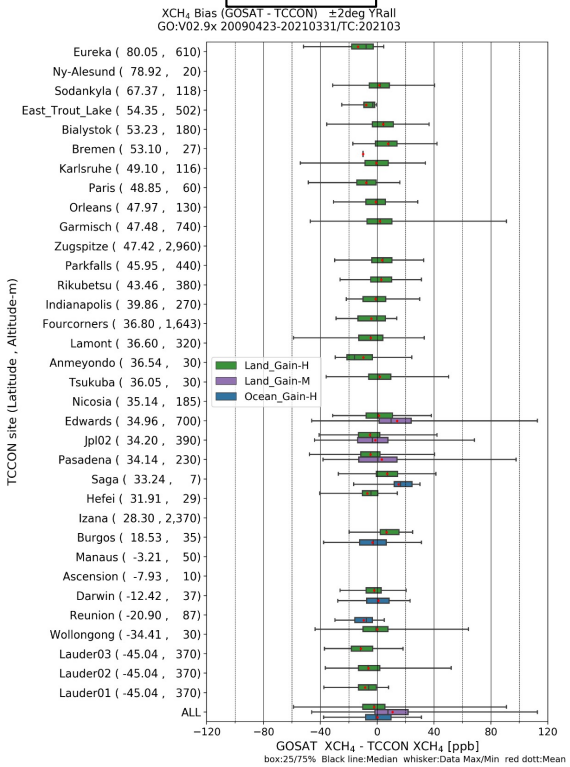
Land Gain H N= 8746	-2.22 ± 12.20 ppb (-0.12 ± 0.67%)	
Land Gain M N= 1591	10.71 ± 19.77 ppb (0.58 ± 1.07%)	
Ocean Gain H N= 139	0.24 ± 13.50 ppb (0.01 ± 0.74%)	

Land Gain H N= 8746	-59.75 ± 376.28 ppm (-1.13 ± 18.98%)	
Land Gain M N= 1591	161.57 ± 580.51 ppm (14.24 ± 35.48%)	
Ocean Gain H N= 139	-110.58 ± 622.99 ppm (-2.12 ± 12.18%)	

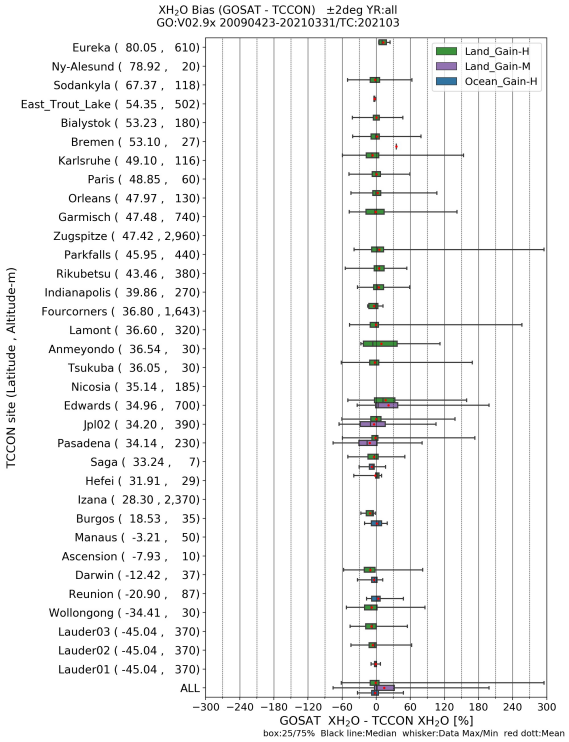
XCO_2



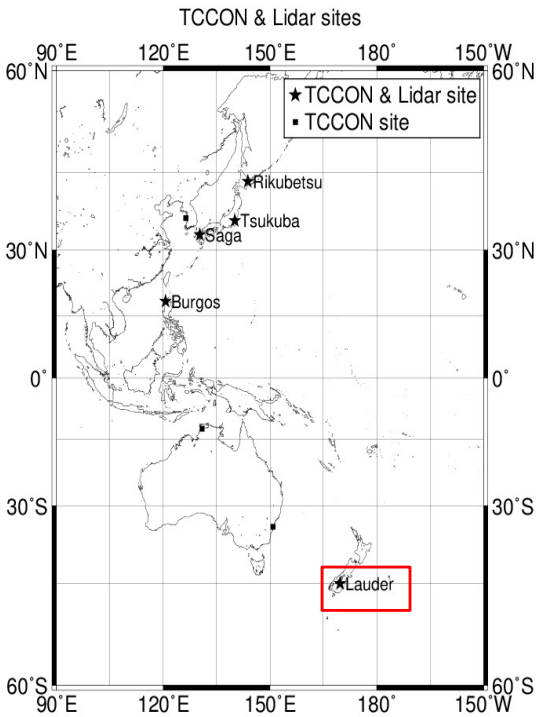
XCH_4



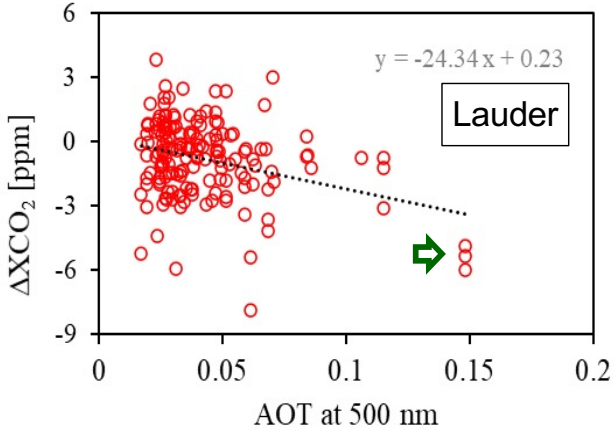
XH_2O



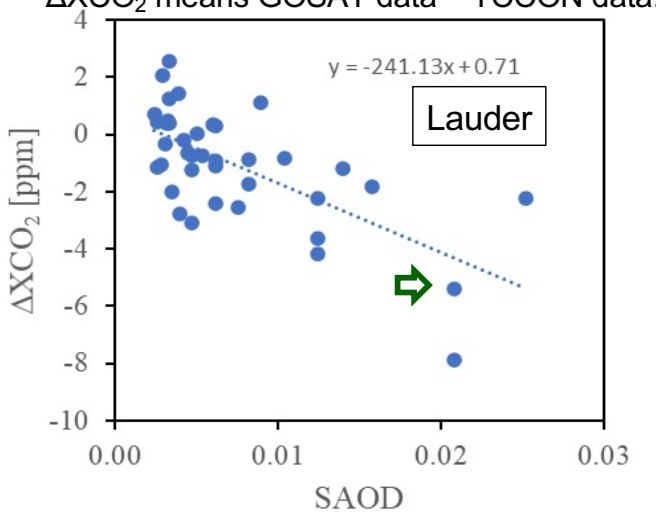
GOSAT FTS SWIR XCO_2 biases by stratospheric aerosols at Lauder



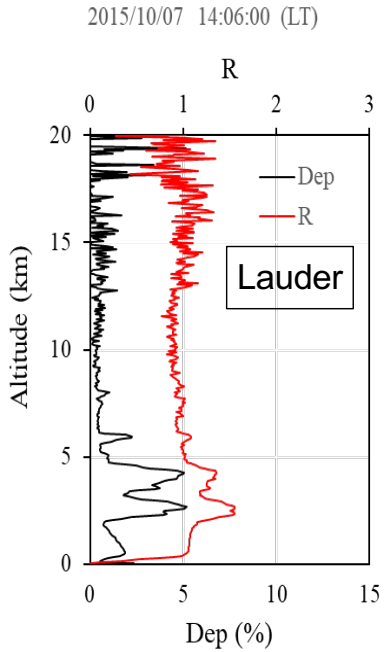
The location map of Lauder.



Scatter plot of AOT and ΔXCO_2 at Lauder.
ΔXCO_2 means GOSAT data – TCCON data.



Scatter plot of SAOD and ΔXCO_2 at Lauder.



Vertical profile of aerosols (depolarization ratio and scatter ratio) by Lidar over Lauder on October 7, 2015.

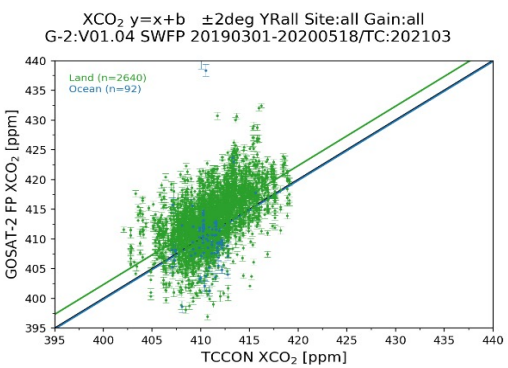
The aerosol observations using sky radiometers and Lidar have been conducted at Lauder, New Zealand. Relatively large AOT (0.15) and very negative ΔXCO_2 (-5.97 ppm) were observed at Lauder on October 7, 2015. This very negative ΔXCO_2 is lower than the value expected from the regression line (dotted line in the figure) in the scatter plot of AOT and ΔXCO_2 at Lauder (the green arrow in the figure).

The stratospheric aerosols, probably originated from Calbuco volcano eruption, were detected by the Lidar measurement on the day in the vertical profile of aerosols. The very negative ΔXCO_2 on the day is supposed to be caused by the stratospheric aerosols. The very negative ΔXCO_2 in the scatter plot of SAOD and ΔXCO_2 at Lauder (the arrow in the right figure) supports this. Here, SAOD is derived by *Sakai et al*. (2016).

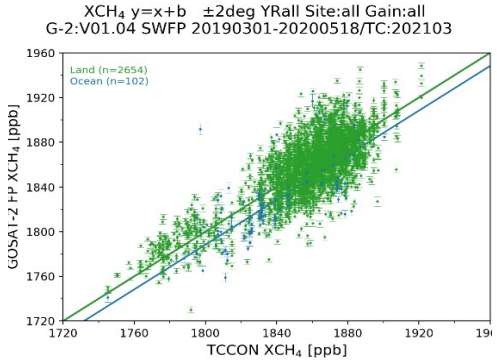
Ref. *Sakai et al*. (2016). *J. Geophys. Res. Atmos*., doi.org/10.1002/2016JD025132.

Analyzed by Dr. Thi Ngoc Trieu Tran

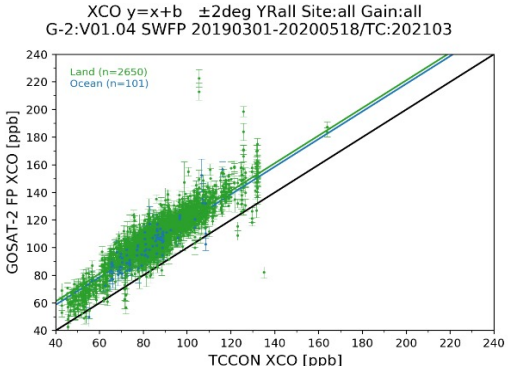
Scatter diagrams of GOSAT-2 FTS SWIR L2 full physics (V01.04) and TCCON at all TCCON sites and differences between them with 1 standard deviation (±2 degree)



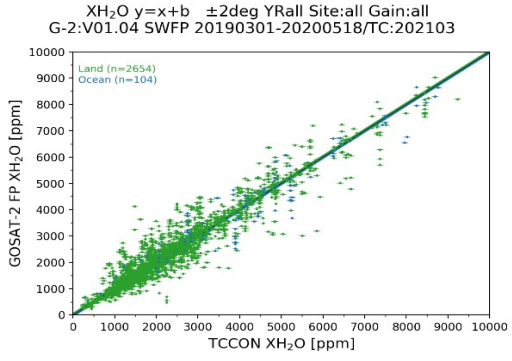
Land 2.34 ± 4.04 ppm (0.57 ± 0.98%)
Ocean -0.14 ± 5.79 ppm (-0.03 ± 1.41%)



Land -0.03 ± 19.33 ppb (0.00 ± 1.04%)
Ocean -11.7 ± 22.97 ppb (-0.63 ± 1.25%)



Land 21.16 ± 8.45 ppb (25.05 ± 10.27%)
Ocean 18.66 ± 7.64 ppb (22.92 ± 8.91%)



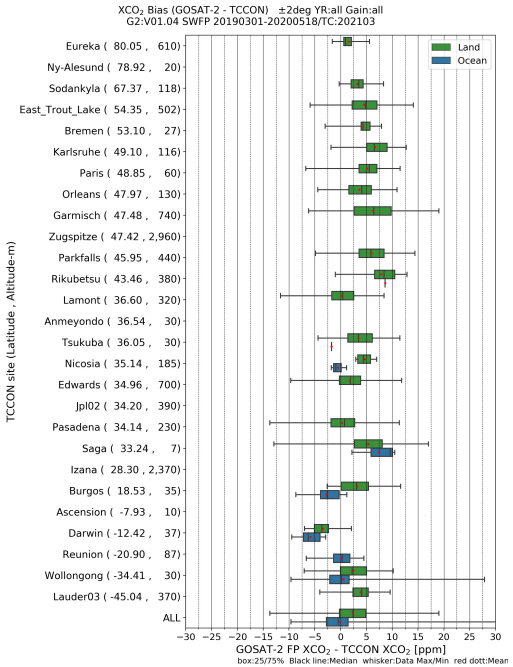
Land 51.84 ± 413.86 ppm (3.86 ± 21.28%)
Ocean -43.76 ± 567.88 ppm (1.40 ± 16.25%)

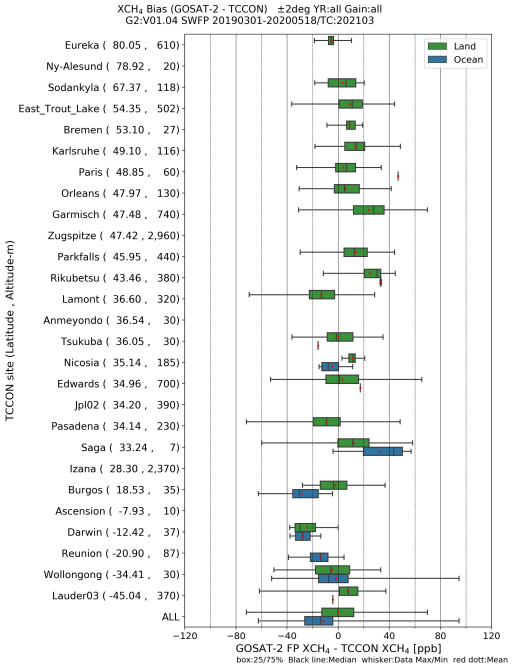
XCO_2

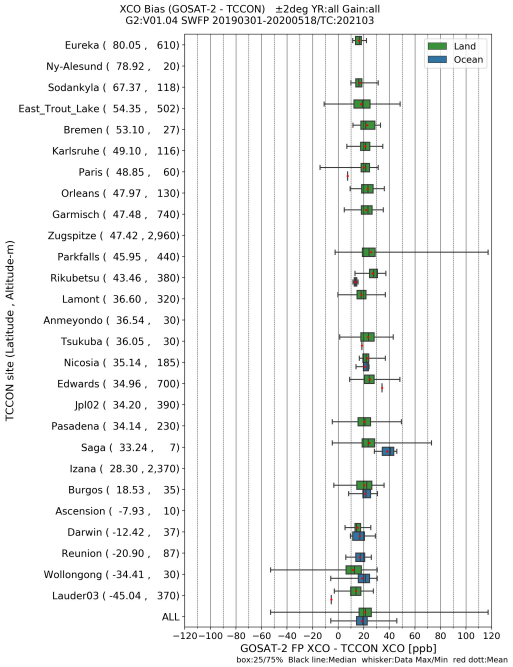
XCH_4

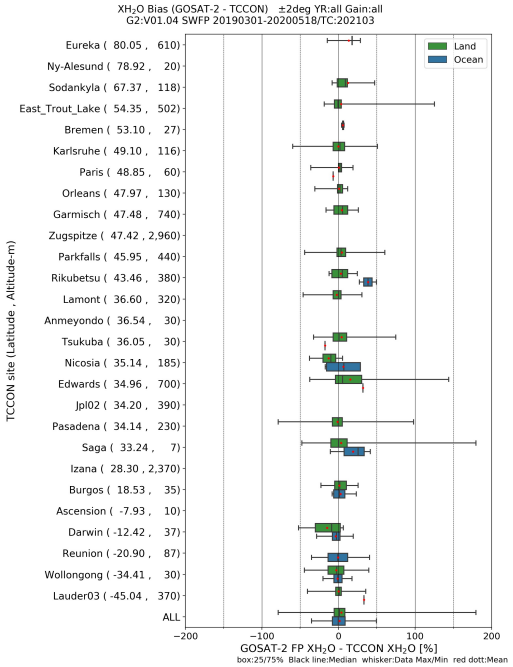
XCO

XH_2O

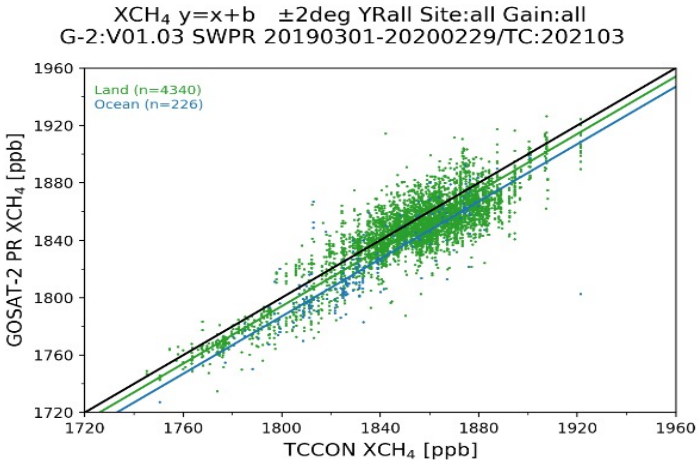




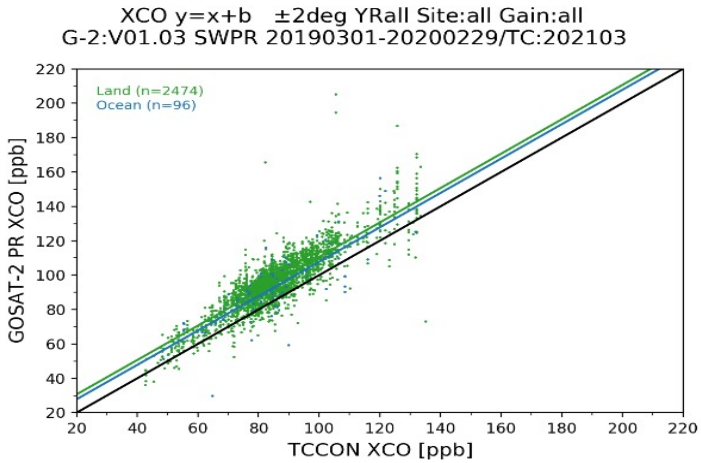




Scatter diagrams of GOSAT-2 FTS SWIR L2 proxy (V01.03) and TCCON at all TCCON sites and differences between them with 1 standard deviation (±2 degree)

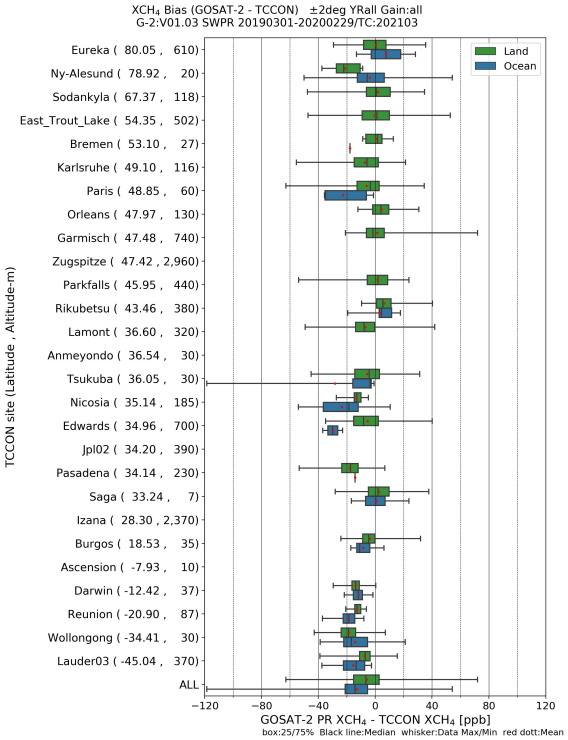


Land -5.93 ± 13.57 ppm (-0.32 ± 0.73%)
Ocean -13.00 ± 15.94 ppm (-0.71 ± 0.86%)

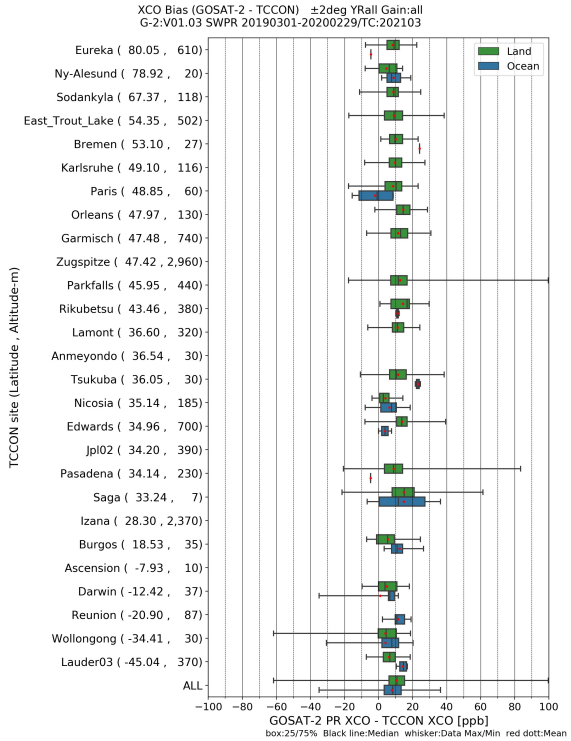


Land 10.63 ± 8.28 ppb (12.55 ± 9.50%)
Ocean 7.79 ± 11.37 ppb (9.55 ± 13.50%)

XCH_4

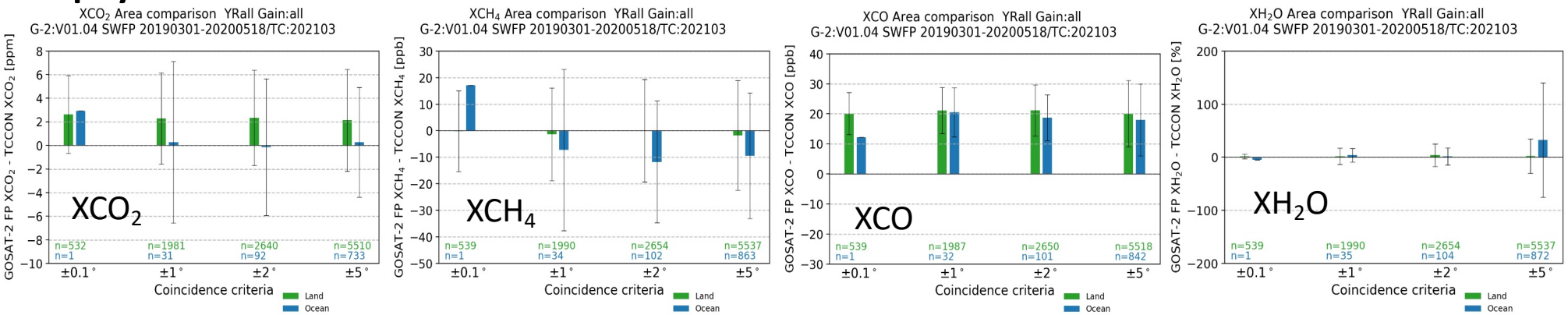


XCO



Biases by coincidence criteria for GOSAT-2 FTS SWIR L2

full physics



The biases of ±0.1º coincidence criteria for Ocean have only one case for XCO_2 and XCH_4, XCO, and XH_2O. So, they are excluded from the analysis.

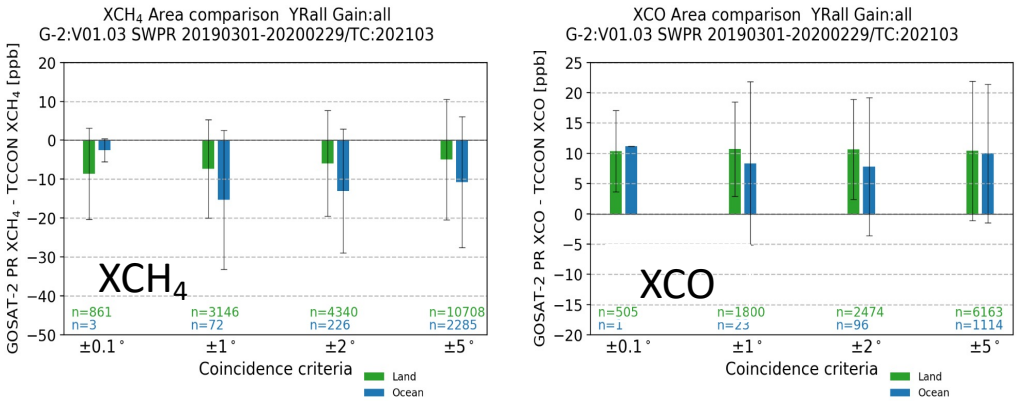
For XCO_2, the biases for Land are all positive and almost constant (~2 ppm) for all coincidence criteria. The biases for Ocean are very small, although the standard deviations are large.

For XCH_4, all of the biases are zero or negative. The absolute biases for Ocean are much larger than those for Land.

For XH_2O, the biases are small except ±5º coincidence criteria for Ocean.

For XCO, the biases of all coincidence criteria are almost constant (~20 ppb), but those for Land are larger than those for Ocean.

PROXY



The numbers of coincidence criteria of ±0.1 for Ocean are very few for both XCH_4 and XCO, so they are excluded in the analysis. For XCH_4, the biases (GOSAT-TCCON) for Land and Ocean are all negative and the absolute biases are decreasing with broadening of coincidence criteria.

For XCO, the biases of every coincidence criteria are almost constant (~10 ppb), but those for Ocean are smaller than those for Land.